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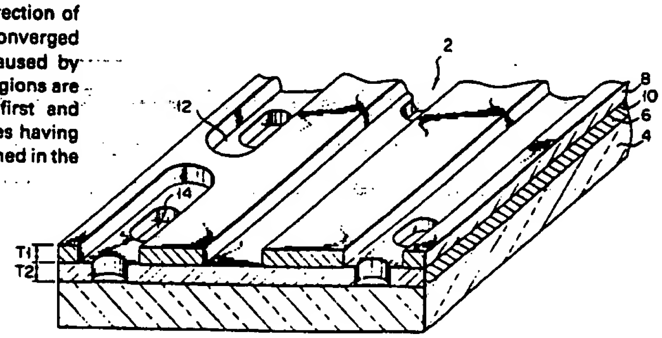
(54) **A master disk for optical disk manufacture, and a method and the system for manufacturing the same.**

(57) In a master disk used for manufacturing an optical disk, first and second layers (6, 8) are formed, in a manner such that they are stacked, on the optically flat surface of a transparent substrate (4). The first and second layers (6, 8) are each formed of a material that can be changed by light, said materials, however, having different sensitivities to light. The first layer is subjected to intermittent projection of a first converged laser beam and is formed with first exposure regions at intervals in the circumferential direction of the disk. The second layer is subjected to continuous projection of a second converged laser beam and is formed with a second exposure region in such a manner that the exposure region extends in the circumferential direction of the disk. Due to projection of the first and second converged laser beams onto the first and second layers caused by passing through a common optical path, the first regions are formed beneath the second region. When the first and second regions are removed, a groove and recesses having prescribed widths and depths, respectively, are formed in the second and first layer (12, 14), respectively.

FIG. 1



EP 0 108 258 A1

A master disk for optical disk manufacture, and a method and the system for manufacturing the same

This invention relates to a master disk for optical disks capable of reproducing and/or recording information and a method and system for manufacturing the same.

Optical disks have been developed which may be applied in various fields as information carriers, from which information may be read out or reproduced and onto which information may be recorded. Such optical disks may include, for example, reproduction-type disks, such as the so-called compact disks for digital audio disk systems; video disks for optical video disk systems; and recording/reproduction-type disks for video file systems or computer output memory systems.

In such optical disks, a tracking guide is formed before recording information onto the optical disk for high-density recording, and pre-pits or preformation pits, such as codes representing the track number and sector number, are pre-formed to specify the recording or readout region. In a conventional information recording/reproducing system, the track number and sector number are read out from the pre-pits while tracing the tracking guide with a laser beam. Subsequently, information pits are formed and information is read out therefrom.

In the conventional optical disk, tracking guides are discontinuously or intermittently formed along its circumference. Flat regions between the circumferential tracking guides are defined as regions in which the information pits are to be formed. Thus, in writing information to form the information pits in the optical disk, there is the risk that the laser beam may deviate from a predetermined track between the tracking guides, and that the information pits may fail to be formed in the prescribed regions. In reading out information from the optical disk in which information pits are formed, rows of information pits between the tracking guides function in the same manner as the tracking guides. Thus, the information pits are traced by the laser beam. However, since the information pits have depths which differ from that of the tracking guide, the rows of information pits have a limited capacity to urge the laser beam to trace the predetermined track. Thus, the laser beam may often deviate from the predetermined track, causing frequent errors.

Regarding the conventional optical disk, moreover, the combination of the width and depth of the pre-pits, and the tracking guide are not fully considered. Thus, information is not read out from the information pits and the pre-pits with satisfactory sensitivity while the tracking guide is being detected.

In order to solve the above-mentioned problems, the present inventors have proposed, as disclosed in U.S. Application Serial No. 511,963 filed July 8, 1983 as well as in EPC application 83106731.9, filed on July 8, 1983, an optical disk wherein the pre-pits are formed in the bottom surface of a groove serving as the tracking guide, the width thereof being made smaller than that of the tracking guide. According to this optical disk, it is possible to cause an increase in the density of information to be recorded onto the optical disk and also to trace the tracking guide of the optical

disk with high precision. However, in the process for manufacturing a master disk for use in the manufacture of such optical disks, when a two step process is used to form the tracking guide and pre-pits, namely when the pre-pits are formed in the tracking guide after the execution of the stop for forming this guide, there is the risk of failure of the pre-pits with a prescribed width and depth formed with high precision in the tracking guide. There is also the risk that the manufacturing of the optical disks will become complicated. For this reason, in the manufacturing of optical disks, it is necessary that the pre-pits be formed with a prescribed width and depth in the tracking guide while this tracking guide is being formed.

Accordingly, an object of the present invention is to provide a master disk which is suitable for manufacturing optical disks having a tracking guide and pre-pits with a prescribed width and depth.

Another object of the present invention is to provide a method for manufacturing a master disk that is suitable in the manufacture of optical disks each having a tracking guide and pre-pits with prescribed width and depth, which permits precise formation, in the same process step, of a groove corresponding to the tracking guide, and recesses corresponding to the pre-pits, of the optical disk.

Still another object of the present invention is to provide a system for manufacturing a master disk, which permits the precise formation, in the same process step, of a groove corresponding to the tracking guide, and recesses corresponding to the pre-pits, of the optical disk.

According to the present invention, there is provided a master disk for manufacturing an optical disk comprising: a substrate having an optically flat surface, a first layer formed on the surface of said substrate with a uniform thickness, formed of material

capable of being changed by laser beam irradiation, and having recesses prepared by removal of a first region irradiated with laser beam, the recesses being arranged at intervals in the circumferential direction of the disk; and a second layer formed on the first layer with a uniform thickness and formed of a material capable of being changed by laser beam irradiation and having a different light sensitivity than the material of the first layer, with a groove made by removing a second region irradiated with laser beam, said groove extending in the circumferential direction of the disk, said recesses being formed in the first layer within the groove.

According to the present invention, there is also provided a method for manufacturing a master disk used in the manufacture of optical disks comprising: the step of irradiating a first converged laser beam intermittently onto an original disk including a substrate having an optically flat surface, a first layer formed on the surface of the substrate so as to have a uniform thickness and formed of a material that can be changed by laser beam irradiation and a second layer formed on the first layer so as to have a uniform thickness and formed of a material that can be changed by laser beam irradiation with a light sensitivity different from that of the first layer, thereby forming first regions in the first layer which are arranged at intervals in the circumferential direction of the disk; and the step of forming the first regions continuously irradiating, at least during formation of the first regions a second converged laser beam onto the original disk, forming a second region in the second layer which extends in the circumferential direction of the disk.

According to the present invention, there is also provided a system for use in the manufacture of a master disk for manufacturing optical disks comprising: a turntable which is rotatable and on which the original

disk of a master disk is to be mounted, an optical head for exposing the original disk of the master disk to light, which includes means for emitting a first laser beam, means for converting the first laser beam into one having a prescribed diameter, first means for modulating the intensity of the converted first laser beam, means for emitting a second laser beam, means for converting the second laser beam into one having a prescribed diameter larger than that of the first laser beam, second means for modulating the intensity of the second laser beam, and an objective lens for converging the modulated first and second laser beams and projecting these beams onto the original disk, forming thereon first and second beam spots having different diameters, concentrically, and a means for moving the optical head in the radial direction of the original disk.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a perspective view of a master disk according to an embodiment of the invention;

Fig. 2 is a schematic view showing an optical system for manufacturing the master disk shown in Fig. 1; and

Figs. 3A to 3F are sectional views showing the process for manufacturing the optical disk from the master disk shown in Fig. 1.

In Fig. 1, there is shown a master disk 2 which is used to manufacture optical disks according to an embodiment of the invention. This master disk 2 has a disk-like substrate with a surface ground and polished into an optically flat surface, (for example, a float glass plate 4 having a thickness of 8 mm). On the optically flat surface of this disk-like substrate 4, there is formed a first layer 6, on which a second layer 8 is formed through an adhesive agent, for example OAP (Trade Mark) manufactured by the Tokyo Ouka company

or TRAN-SIL (Trade Mark) manufactured by Tran-sil Product incorporated, serving to increase the strength of adhesion between this second layer 8 and the first layer 6. First layer 6 and second layer 8 are formed of material that can change with respect to light or a laser beam, but, materials with different sensitivities are selectively used for the first and second layers, respectively. For example, selective use is made, for material in the first layer 6, of semi-metals such as Te, Bi, Se, etc. or metals such as Cr, Aℓ, etc.. The compounds of these metals can be deformed or evaporated by heating, and the substances capable of being sublimed by heat such as nitrocellulose containing organic pigment or carbon, or photo-resist. Similarly, selective use is made, for material in the second layer, of substances that can be thermally sublimed such as nitrocellulose containing organic pigment or carbon, or photo-resist, or the like. For material in the first layer 6, use may be made of other substances with the capability of being thermally deformed or gasified (gasification is used, in this specification, to mean boiling, evaporation and sublimation). The thickness T1 of the second layer 8 is set at a value substantially equal to a depth H1 of a tracking guide of the optical disk, namely $(\frac{2n-1}{4}\lambda - \frac{\lambda}{8})$. The preferred thickness T2 of the first layer 6 is set at a value obtained by subtracting the depth H1 of the tracking guide from a depth H2 of pre-pits of the optical disk. The depth H2 of the pre-pits is determined to have a value of $(\frac{2m-1}{4}\lambda)$, and the thickness T2 of the first layer is determined to a value (H2 - H1). Note here that n and m and each integers, preferably n = m, and the λ indicates the wavelength of a laser beam to be projected onto the optical disk from which information is read out and/or onto which information is recorded.

The above-mentioned first and second layers 6, 8 are spirally or concentrically formed, along the

circumferential direction of the optical disk 2, with grooves 12 corresponding to the tracking guide and recesses 14 corresponding to the pre-pits, as shown in Fig. 1, by means of a system shown in Fig. 2 which will be described later. The width C1 of this groove 12 is set at a value of Wo/2 while the width C2 of the recess 14 at a value of Wo/3. It should be noted here that Wo is defined as the diameter of a region in which the light intensity is at least $1/e^2$ of the maximum light intensity obtained in the light intensity distribution of a beam spot formed on the master disk.

Next, the process for manufacturing the master disk 2 shown in Fig. 1, will be described with reference to Fig. 2. In the system shown in Fig. 2, an original disk 18 of the master disk 2 having the substrate 4 formed with the first and second layers 6, 8, thereon, without the groove 12 and recess 14, is put on a turntable 16 rotatable at constant linear velocity by a drive motor 20. In this embodiment, this original disk 18 is comprised of the second layer 8 consisting of a positive photoresist and the first layer 6 consisting of material containing Te as the main component and a suitable amount of carbon mixed therein. The first and second layers 6, 8 are subjected to light exposure by an exposing optical head 22 shown in Fig. 2 in such a manner that their first and second regions 24, 26, to be formed with the recesses 14 and grooves 12, respectively, are exposed to the light.

The exposing optical system 22 includes first and second laser units 30 and 34. Use is made, in the first laser unit 30, of a He-Ne laser unit capable of projecting He-Ne laser beams 28 to expose the first layer 6, that is, He-Ne laser beam 28 suitable for evaporating the Te constituting the material of the first layer 6. For the second laser unit 34, an Ar laser unit is used, which can emit an Ar laser beam 32 to the second layer 8. An Ar laser beam is

considered optimum in view of spectral sensitivity of the photo-resist constituting the material of the second layer 8. The reason the first and second laser units 30, 34 emit laser beams of different wavelengths is that the laser beams can be separated by a dychroic mirror 42 even as they pass along the same optical path within the exposing optical system 22. The first laser beam 28 emitted from the first laser unit 30 passes through a collimator lens system 36 comprised of a divergent lens and convergent lens and is thus converted into a parallel laser beam having a prescribed diameter. The resultant laser beam 28 is subjected to light intensity modulation by a first modulator 38, or chopped thereby, according to the desired code information. The laser beam 28, thus chopped, is linearly polarized by means of a first polarization beam splitter 40 and is directed to a mirror 44 through the dychroic mirror 42 designed to reflect only the second laser beam 32. The laser beam 28 reflected from the mirror 44 is incident on an objective lens 48 through a $\lambda/4$ plate 46 along its optical axis, is converged and is thus projected onto the original disk 18 by the objective lengs 48. The optical elements of a first optical system through which the first laser beam passes are arranged so that the first laser beam 28 projected onto the original disk 18 may have a first beam spot of substantially Wo/3 diameter on a bundary plane between the first and second layers 6 and 8. The second laser beam 32 emitted from the second laser unit 34, similarly, passes through a collimator lens system 50 comprises of a divergent lens and a convergent lens and is converted into a parallel laser beam having a prescribed beam diameter larger than that of the first laser beam 28. The second laser beam 32 is subjected to light intensity modulation or chopped by a second modulator 52 according to information regarding the region to be form d by a tracking guide.

The laser beam, thus chopped, is linearly polarized by a second polarization beam splitter 54 and is then reflected by the dychroic mirror 42 and is directed to the mirror 44. The laser beam 32 thus reflected by this mirror 44 is allowed to pass through a λ/4 plate and then through an objective lens 48 along the optical axis to be projected onto the original disk 18. On the surface of the second layer 8 of the original disk 18, a second beam spot having a diameter of Wo/2 is formed, concentrically with said first beam spot, by an optical system through which the second laser beam 32 is allowed to pass.

In the above-mentioned optical system, when the objective lens 48 is kept out of focus, or in defocus-state in which the beam spot of prescribed diameter is not formed on the original disk 18 of the master disk 2, the objective lens 48 is moved along the optical axis by a voice coil 56, whereby the objective lens 48 is maintained in a state of "in-focus" wherein the beam spot having the prescribed diameter is formed on the original disk 18. That is, the first laser beam 28 reflected from the original disk 18 and allowed to pass through the objective lengs 48, λ/4 plate 46, dychroic mirror 42 and beam splitter 40 is allowed to enter a focus detecting section 64 from known convergent lens 58, cylindrical lens 60 and photodetector device 62. In accordance with the photo-signals generated from the photodetector device 62, a focussing signal generator 66 generates a focussing signal which is then applied to a voice coil driver 68 in a known manner. The voice coil 56 is thereby driven, and the objective lens 48 is kept in a constant state of "in-focus".

Any of the first and second laser beams 28, 32 reflected by the original disk 18 toward the first and second laser units 30, 34, are interrupted by the beam splitter 40 or 54, and the laser unit 30 or 34 is prevented from being brought to an undesired state.

As mentioned above, the first laser beam 28 is intermittently projected from the modulator 36 onto the original disk 18 rotating at a constant linear velocity and the second laser beam 32 is intermittently or continuously projected from the modulator 52 onto the rotating original disk. When such projection is made, the second layer 8 is exposed, by the second laser beam 32 and an exposed second region 26 having a prescribed width is intermittently or continuously in the circumferential direction of the original disk 18. On the other hand, the first laser beam 28 passes through the second layer 8 to reach the first layer 6 to cause the evaporation of Te of the first region 24, thereby causing this first region 24 to be recessed. Accordingly, the original disk 18 is formed with the exposed second region 26 in a circumferential direction and also intermittently formed, below the second region 26, with the recessed shaped first region 24. When, in the exposure process, the optical system 22 is moved by a linear actuator 70 in the radial direction of the original disk 18, this disk is formed with the first and second regions 24, 26, concentrically or spirally.

When the original disk 18, exposured in the above-mentioned process is subjected to a developing and fixing treatment, the second region 26 is removed, and a master disk 2 such as that shown in Fig. 1 is completed. By use of this master disk 2, an optical disk 72 is manufactured as follows.

First, a master disk 2 is plated, as shown in Fig. 3A, to form the replica 74 shown in Fig. 3D. Then, a base disk 76 made of, e.g., transparent synthetic resin, as shown in Fig. 4C, is formed by the use of the replica 74 shown in Fig. 3B, and a metal layer is deposited on the surface of the base disk 76 to form a light reflective recording layer 78, shown in Fig. 3D. The base disk 76 is worked into a predetermined shape, and is pasted onto a disk plate 80 made of glass or

some other material, as shown in Fig. 3E. A pair of disk plates 80, each provided with the base disk 76, are pasted together with a spacer 82 between them, as shown in Fig. 3F, to complete the optical disk 72.

As stated above, according to the present invention, it is possible to precisely form the region corresponding to the tracking guide and, during this formation, form the region corresponding to the pre-pits at the position located beneath that region. Thus, it is possible to more precisely manufacture the master disk for manufacturing the optical disk.

Claims:

1. A master disk for manufacturing optical disks comprising

a substrate (4) having an optically flat surface, characterized by further comprising

a first layer (6) formed on the surface of said substrate (4) so as to have a uniform thickness and formed of a material capable of being changed by laser beam (28) irradiation and having recesses (14), each prepared by removal of a first region (24) thereof irradiated with a laser beam (28), said recesses being arranged at intervals in the circumferential direction of the disk (2); and

a second layer (8) formed on said first layer (6) so as to have a uniform thickness and formed of a material capable of being changed by laser beam (32) irradiation, this material having a different light sensitivity from that of the material of said first layer (6), and having a groove (12) made by removing a second region (26) thereof irradiated with laser beam, said groove (12) extending in the circumferential direction of the disk (2), said recesses (14) being formed in said first layer (8) within said groove (12).

2. A master disk according to claim 1, characterized in that said recesses (14) correspond to pre-pits of said optical disk and said groove (12) corresponds to a tracking guide of said optical disk.

3. A master disk according to claim 1, characterized in that said first layer (6) is formed of a material capable of being deformed or gasified by heat generated by laser beam (28) applied to said second layer (8) formed of photo-resist.

4. A master disk according to claim 1, characterized in that said second layer (8) has a thickness T2 and said first layer (6) has a thickness T1 determined by the following formulas:

$$T2 = \left(\frac{2n - 1}{4} - \frac{1}{8}\right)\lambda$$

$$T1 = \left(\frac{2n - 1}{4} - \frac{1}{8}\right)\lambda - \left(\frac{2m - 1}{4}\right)\lambda$$

where n, m = 1, 2, 3,..., and λ represents the wavelength of a laser beam to be irradiated onto said optical disk.

5. A master disk according to claim 1, characterized in that said groove (12) has a width of Wo/2 and said recesses (14) have a width of Wo/3, said Wo being defined as the diameter of a region in which the light intensity is at least $1/e^2$ of the maximum light intensity obtained in the light intensity distribution of a beam spot formed on the master disk (2).

6. A method for manufacturing a master disk used in the manufacture of optical disks characterized by comprising:

the step of applying a first converged laser beam (28) intermittently onto an original disk (18) including a substrate (4) having an optically flat surface, a first layer (6) formed on the surface of said substrate (4) so as to have a uniform thickness and formed of a material that can be changed upon irradiation of laser beam (28) thereon and a second layer (8) formed on said first layer (6) so as to have a uniform thickness and formed of a material that can be changed upon application of a laser beam (32) thereon and which has a light sensitivity different from that of said first layer (6), thereby forming first regions (24) in said first layer (6) arranged at intervals in the circumferential direction of the disk (2); and

the step of continuously applying a second converged laser beam (32) onto said original disk (18) at least during the formation of said first regions, thereby forming a second region (26) in said second layer (8) which extends in the circumferential direction of the disk.

7. A method according to claim 6, characterized by

further comprising the step of removing said second region (26).

8. A method according to claim 7, characterized by further comprising the step of removing said first regions (24).

9. A method according to claim 6, characterized in that said first and second converged laser beams (28, 32) has different wavelengths, respectively.

10. A method according to claim 6, characterized in that said second layer (8) has a thickness T2 and said first layer (6) has a thickness T1 determined by the following formulas:

$$T2 = \left(\frac{2n-1}{4} - \frac{1}{8}\right)\lambda$$

$$T1 = \left(\frac{2n-1}{4} - \frac{1}{8}\right)\lambda - \left(\frac{2m-1}{4}\right)\lambda$$

where n, m = 1, 2, 3,..., and λ represents the wavelength of laser beam to be applied to said optical disk.

11. A method according to claim 6, characterized in that said second region (26) has a width of Wo/2 and the said first regions (24) have a width of Wo/3, said Wo being defined as the diameter of a region in which the light intensity is at least $1/e^2$ of the maximun light intensity obtained in the light intensity distribution of a beam spot formed on the master disk (2).

12. A method according to claim 6, characterized in that said first and second converged laser beams (28, 32) is projected onto the original disk (18) through a common optical path.

13. A system for use in manufacture of a master disk of optical disks comprising a turntable (16) which is rotatable and on which an original disk (18) of a master disk (2) is to be mounted, characterized by further comprising:

an optical head (22) which is used to expose said original disk (18) of said master disk (2) and which includes means (30) for emitting a first laser beam (28),

means for converting said first laser beam (28) into one having a prescribed diameter, first means (36) for modulating the intensity of said first laser beam (28), a means (34) for emitting a second laser beam (32), means for converting said second laser beam (32) into one having a prescribed diameter larger than that of said first laser beam (28), second means for modulating the intensity of said second laser beam (32), and an objective lens (48) for converging said modulated first and second laser beams (28, 32) and projecting these beams (28, 32) onto said original disk (18), thereby to concentrically form thereon first and second beam spots having different diameters; and

a means (70) for moving said optical head (22) in the radial direction of said original disk (2).

14. A system according to claim 13, characterized in that said first and second laser beams (28, 32) have different wavelengths.

15. A system according to claim 13, characterized in that said optical head (22) includes a means (56) for moving said objective lens (48) along an optical axis thereof.

16. A system according to claim 15, characterized by further comprising a means for energizing said moving means (56) by sensing one of said first and second laser beams (28, 32) reflected from said original disk (18), thereby moving said objective lens (48), to keep the beam spots at a prescribed diameter at all times.

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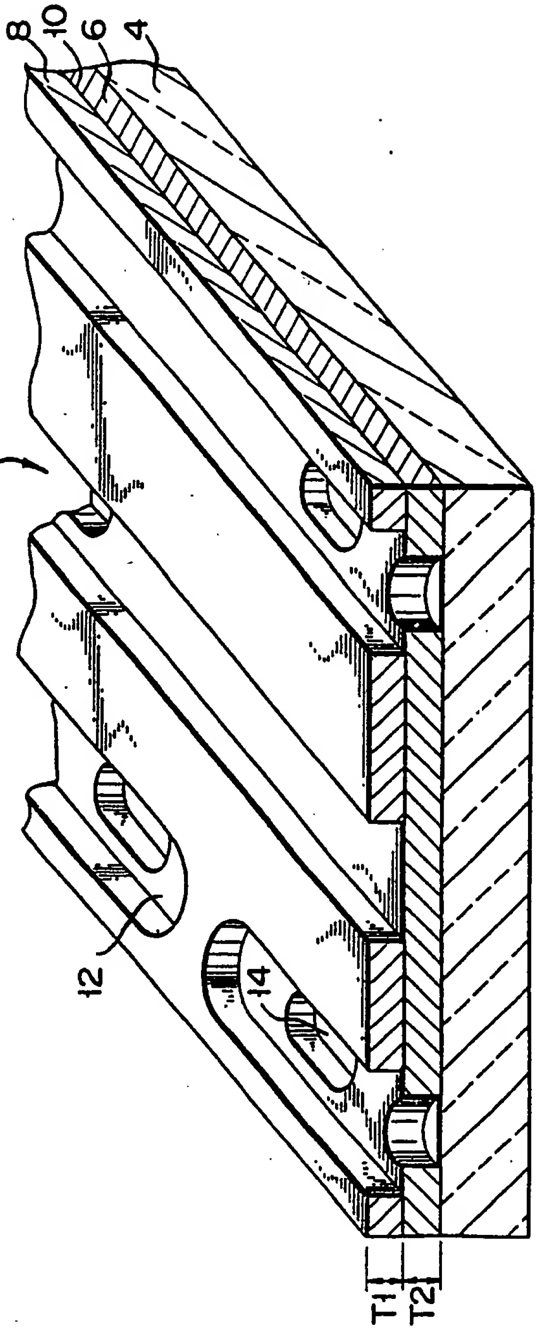
FIG. 1



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F I G. 2

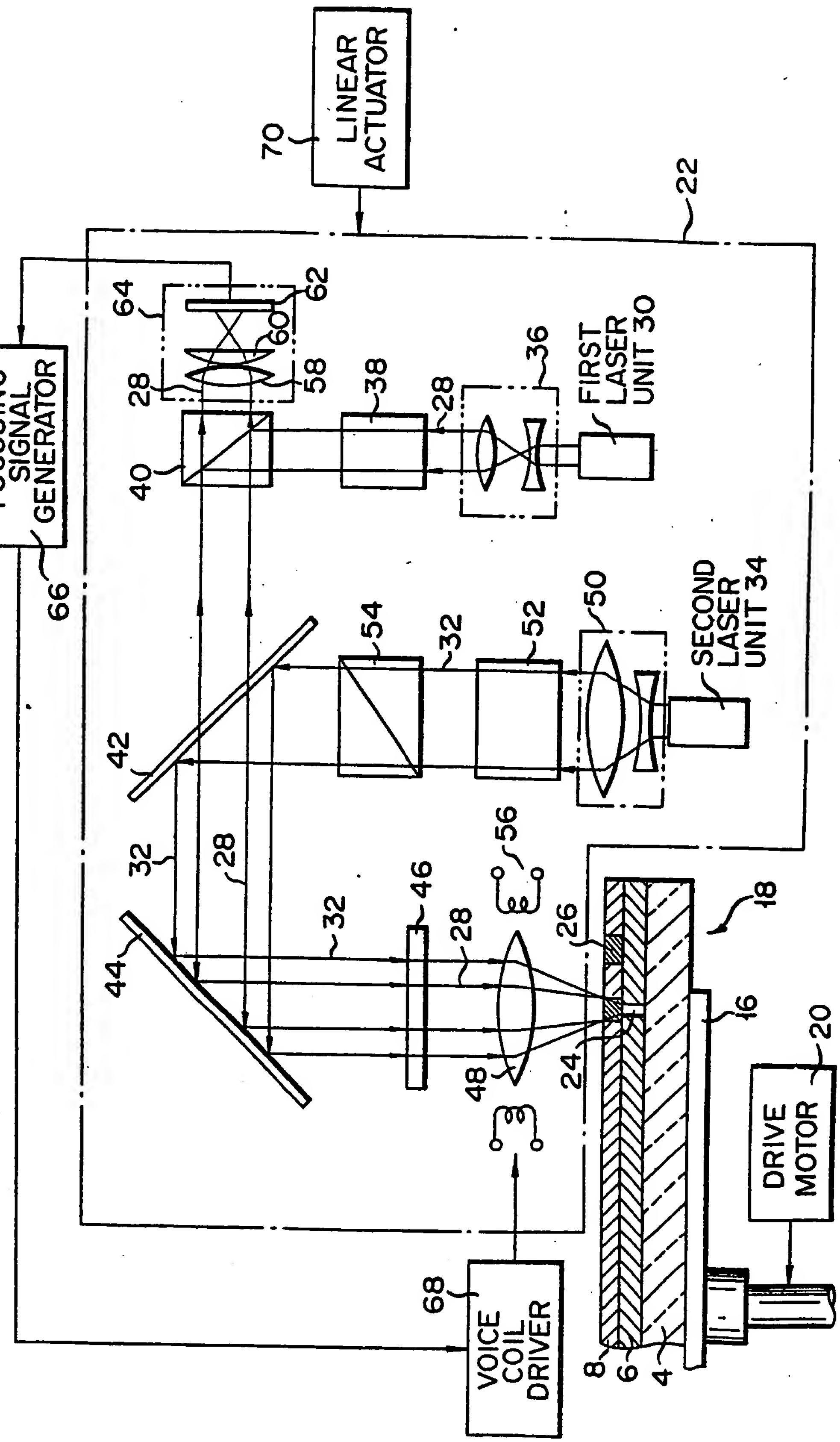


FIG. 3A

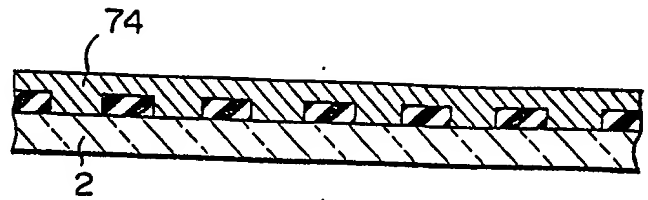


FIG. 3B

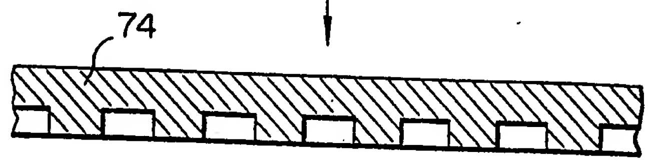


FIG. 3C

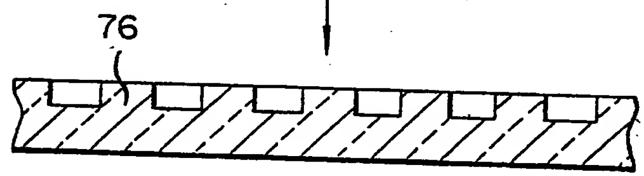


FIG. 3D

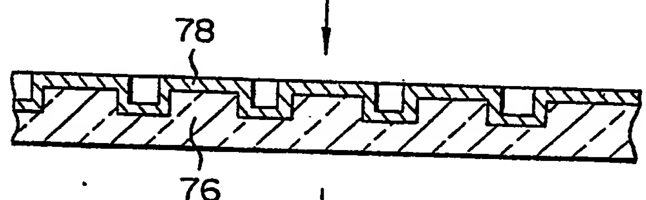


FIG. 3E

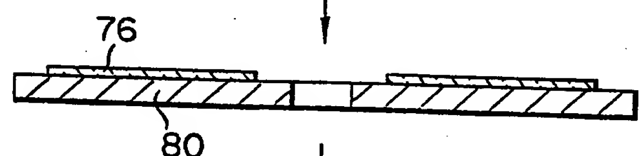
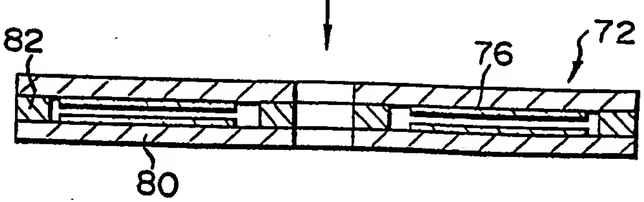


FIG. 3F



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EUROPEAN SEARCH REPORT

Application number

EP 83 10 9976

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
Y	PATENTS ABSTRACTS OF JAPAN, vol. 6, no. 156(P-135)(1034), 17th August 1982 & JP - A - 57 74834 (FUJITSU K.K.) 11-05-1982 * Abstract * ---	1-16	G 11 B 7/26 G 11 B 7/24 // G 03 F 7/20
Y	GB-A-2 091 028 (PHILIPS') * Page 3, lines 36-65; page 6, lines 39-59; figures 1,2; claims * ---	1-16	
A	PATENTS ABSTRACTS OF JAPAN, vol. 6, no. 59(P-110)(937), 16th April 1982 & JP - A - 56 169 235 (HITACHI SEISAKUSHO K.K.) 25-12-1981 * Abstract * ---		
A	EP-A-0 039 094 (AGFA-GEVAERT) ---		TECHNICAL FIELDS SEARCHED (Int. Cl. 3)
A	DE-A-2 026 805 (PRECISION INSTRUMENT) ---		G 11 B 23/00 G 11 B 7/00 G 03 F 7/00
A	DE-A-2 355 446 (CANON) ---		
A	EP-A-0 017 289 (PHILIPS') --- -/-		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	02-02-1984	PHILOSOPH L.P.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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D : document cited in the application
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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 3)
E,L	EP-A-0 099 085 (TOKYO SHIBAURA DENKI) * Page 3, line 35 - page 8, line 17; figures 2,8-11C; claims 1-6,9,18 *	1-16	

			TECHNICAL FIELDS SEARCHED (Int. Cl. 3)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	02-02-1984	PHILOSOPH L.P.

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T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
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